their data may be regarded as fairly accurate. The fireball was seen at a low altitude in the southern or south-eastern sky, and it moved very slowly in a very long horizontal flight, distributing sparks as it sailed along, and finally breaking up into fragments.

The radiant was at 145°+8°, and the height of the object from 55 to 44 miles, length of luminous course 275 miles, and velocity 18 miles per second.

The recent fireball was a brilliantly conspicuous object, though the full moon had just risen, and many people mistook it at first for a rocket-like firework on account of its vividness, slow motion, and final burst into spark fragments.

RELATIVE MASSES OF BINARY STARS.—Any increase in our knowledge of the masses of the stars is of great value from a physical point of view, since it throws light on the correlation of mass with spectral type. Mr. G. van Biesbroeck, in *Popular Astronomy* for January, states that photographs of binary stars are now being taken with the Yerkes refractor to determine the motion of each star of the pair, as referred to the background of faint stars, and so obtain the relative masses. Photographs of Castor were taken in the years 1916 to 1919, and give the annual motion of the bright component in R.A. −0·0167s., and for the faint component −0·0118s. Assuming Boss's value for the motion of the centre of gravity, viz. −0·0135s., it results that the faint star is 1·9 times as massive as the bright one. The weakest point is the assumption of the motion of the centre of gravity. Boss assumed equal masses; but since a value identical with his was published in Monthly Notices R.A.S. for 1907 on the assumption that the faint star is six times as massive as the bright one, it would seem that the value −0·0135s. is close to the truth.

The systems of Procyon and ζ Cancri are also being investigated. It is hoped in the former case to fill up the gap in the orbit in the region where the faint star is too near to the primary to observe.

LONG-PERIOD VARIABLES.—Several years ago the Rev. T. E. R. Phillips proposed a division of these variables into Groups I. and II., which differ in the relation to each other of the first and second harmonics, when the magnitude variation is developed in a Fourier's series. Prof. Turner and Miss Blagg contributed a paper to the Monthly Notices R.A.S. for November on the star W Cygni, analysis of the light-curve of which suggested that this star is in the act of passing from Group II. to Group I. A further paper by Prof. Turner was read at the January meeting of the Royal Astronomical Society, in which he examined the observations of several stars of Group II., for which Prof. Chandler gave a secular change of period. The analysis indicates in every case a diminution of period, but seems to show that this takes place by sudden jumps, not by a steady, continuous process, such as Chandler's formula implies. It is suggested that the period decreases to a minimum value, after which the star passes into Group I., and its period then increases again.

It was formerly the idea that these red variables were near the end of their career as suns, but from a study of their proper motions, which seem to be very small, it is inferred that they are giants, near the commencement of their career. From the case of our sun, which is an incipient dwarf star, with a sun-spot variation period much longer than that of any known variable, we may conjecture that after passing into Group I. the period continually lengthens, while the amplitude diminishes and becomes practically inappreciable, except in the case of the sun, the surface of which can be studied in detail.

AUSTRALIAN SIGNPOSTS.

IN the Records of the South Australian Museum for August, 1919,[1] Mr. E. R. Waite completes a description of the Toas or direction signs of the Australian aborigines which was partly translated and arranged from the manuscript of the late Rev. J. G. Reuther, of the Lutheran Mission, by the late Sir Edward Stirling.

The description is prefaced by a summary account of the religious beliefs of the Diari and associated tribes in the district east of Lake Eyre, in South Australia. According to Mr. Reuther, these believed in a single Supreme Being called *Mura*, who was great, powerful, beautiful, omnipresent, righteous, and omniscient. *Mura* created a number of demi-gods—*Muramura*—some perfect and others imperfect, with their wives or subjects—*Mili*. The *Muramura* were the ancestors of mankind. They wandered about the country, and the legends of the natives are the records of their journeys and adventures. Native songs and invocations were addressed to them. The *Muramura* named all things, and many of the natural features of the country are ascribed to them. They named each of their camps from something noticed there, and these are the native place-names of the district.

On the death of a *Muramura* his body usually changed to a stone, which was venerated by his descendants. Sun, moon, and the constellations were also regarded as abodes of departed *Muramura*.

The Toas are thus described. They consist mostly of a piece of flattened wood (usually from 6 in. to 18 in. in length), "pointed at one end, and either coloured or plastered over with white clay, which itself may be coloured uniformly or marked with simple designs. At the upper end the clay is frequently moulded into a spherical or oval knob, and this also may be plain or variously coloured or have inserted some object typical of the locality or symbolical of a Muramura's adventure, such as a tuft of grass, twigs, feathers, hair, etc., pieces of bone, charcoal, or a model of some weapon or utensil. In a considerable number of Toas the upper end is modelled into a representation of some part of the human body, such as the hand, head, or foot, or into that of the whole or some part of a bird, fish, or other animal."

More than three hundred coloured illustrations of Toas contained in the museum collection are given. They show a surprising variety of form and ornamentation. Each Toa has a name which is a native place-name with the suffix *-ni* or *-ri*, meaning "direction towards." Four of the figures, with their explanations, are here given as examples. They are Nos. 1, 14, 66, and 187.

"1. *Dakarawitjarini* (Diari Tribe).—The word means a hard flat or plain, where Emus run to and fro, and it originates from the legend of the Muramura, Ngurakarlina, who, coming to the place, saw many of these birds running about.

"The longitudinal, vertical, and partly sinuous black stripe on the Toa represents a salt creek, the oval patch being a deep waterhole, and the lateral branches tributary creeks. Surrounding these is the plain where the Emus used to run, the white spots indicating bushes and scrub. This is the largest Toa in the collection, being over five feet in length."

"14. *Mararuni* (Wonkanguru Tribe).—To the hand

1 "Description of Toas, or Australian Aboriginal Direction Signs." Being an Abstract from the J. G. Reuther Manuscript by the late Sir Edward Stirling, F.R.S., Hon. Curator in Ethnology, and Edgar R. Waite, Director, South Australian Museum. Pp. 105–55+plates xi–xx Public Library, Museum, and Art Gallery of South Australia. Records of the South Australian Museum. Edited by the Museum Director. Vol. i., No. 2. (Adelaide: Published by the Board of Governors, August 30, 1919.)

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with four fingers, the Toa representing a four-fingered hand. The Muramura, Wutjukana, had a servant whose index and middle fingers had partly grown together, as indicated by the Toa. The Toa also has a geographical significance, for when Wutjukana came to a gorge which divided into four branches, one being deeper than the others, he said to himself, 'This place looks like the hand of the servant,' and so he gave it this name."

"66. *Witjikurawinpani* (Tirari Tribe).—To the tracks of the whirlwind in the sand. When the Muramura, Patjalina, once came, hunting, to this place, he noticed that a whirlwind had passed over it, which had effaced the tracks of animals and had swept together a litter of leaves and grass; hence he named

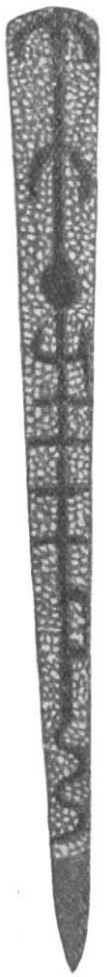

FIG. 1.

FIG. 2.

FIG. 3.

IG. 4.

it thus. The white knob represents a sandhill overgrown with bushes (red dots) which adjoins Cooper's Creek. The crescent-shaped, black figure below indicates the creek itself, and the black vertical band a deep waterhole at the foot of the hill, which has been washed out by a flood. The surrounding borders of white and yellow signify soil of these colours, and the white spots trees."

"187. *Muramurawintini* (Tirari Tribe).—To the Muramura's hair. So named because on this plain the Muramura, Patjalina, tore out his hair and threw it away. The white colour represents the plain, with watercourses (red and yellow stripes), and, in accordance with the name, the Toa bears a tuft of hair."

When a native is about to remove to another camp he makes a Toa representing the locality to which he is removing and sticks its pointed end into the earth of the camp which he is leaving. Signs are made on the ground directing attention to its presence. His friends who arrive later recognise the significance of the Toa, and are thus made aware of the place to which he has gone.

The whole collection and its elucidation form a most interesting contribution to the study of Australian symbolism. SIDNEY H. RAY.

HUMAN METABOLISM.[1]

THE first of the monographs before us deals with the prediction of basal metabolism from a knowledge of individual physical and biological constants. The usual process has been to multiply the subject's surface area, as deduced from the height and weight by du Bois's method, by the average Calorie output per square metre determined from a "standard" series, it being assumed that the metabolism per unit area in adults is approximately constant. The order of the error involved and the improvement effected by Drs. Harris and Benedict's process can be gauged by the following example. In these authors' series of 136 adult males, the mean twenty-four hours' basal output was 1631·7 Calories with a standard deviation of 204·7 Calories; the latter is 12·5 per cent. of the mean. The corresponding mean per square metre of surface was 925·5 Calories with a standard error of 74·5 Calories, about 8 per cent. of the mean.

It follows that if the distribution around the mean be assumed to be normal (actually, using a coarse unit of grouping, we find that the authors' series for women is in good agreement with a normal distribution; the series for men is somewhat less regular, but not a very improbable sample from a normal population), the assignment of 925·5 Calories per square metre as the basal metabolism of an unknown individual is subject to a standard error of ±8 per cent. But if a prediction is based upon a multiple regression equation of the first degree, the other variables used being height, weight, and age, the standard error of the prediction falls from 204·7 Calories to 101·7 Calories, or the *average* percentage is 6·2.

These remarks assume that the correlation is normal correlation. As this may not be the case, and as a complete study of the form of the regression cannot profitably be made without a larger collection of data, the authors have empirically tested the accuracies of the several methods, comparing the predictions based on their equations for samples not utilised in the calculation of the constants with those afforded by the surface rule. In nearly every case the regression equations give results closer to the truth than does the surface rule.

We may illustrate with a couple of examples taken at random from the data. A man aged twenty-nine, weighing 66 kg. and 177 cm. tall, had a basal metabolism of 1695 Calories. The surface rule would assign 1675 Calories, with a standard error of 135; the multiple regression formula gives 1664 Calories, with a standard error of 102. Here both results are good. In another case a man aged forty-three, weighing 58·5 kg. and 181 cm. tall, had a basal meta-

[1] (1) "A Biometric Study of Basal Metabolism in Man." By J. Arthur Harris and Francis G. Benedict. Publication No. 279. Pp. vi+266. (Washington: The Carnegie Institution of Washington, 1919.)

(2) "Human Vitality and Efficiency under Prolonged Restricted Diet." By Francis G. Benedict, Walter R. Miles, Paul Roth, and H. Monmouth Smith. Publication No. 280. Pp. xi+701. (Washington: The Carnegie Institution of Washington, 1919.)

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